

Demonstration, Operation, and Testing of a
Fabric Filter on an Industrial Boiler for an
Extended Period of Time

ETS, Inc., Roanoke, VA

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DEMONSTRATION, OPERATION, AND TESTING OF A
FABRIC FILTER ON AN INDUSTRIAL BOILER
FOR AN EXTENDED PERIOD OF TIME

by

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16. ABSTRACT The report gives results of an evaluation of gas-to-cloth (G/C) ratios and a variety of fabrics in baghouses controlling particulate emissions from coal-fired industrial boilers. Procedures for increasing the G/C ratio were evaluated in a pulse-jet baghouse. A second baghouse of the same size, but with reverse-flush cleaning, was used to study several types of woven and felted fabrics. Typical of textile plant boiler operations, the baghouses were subjected to fluctuating load requirements and frequent dewpoint excursions. Under these conditions, it was found that off-line high energy pulse-jet cleaning was necessary for long term pressure drop stability at G/C ratios above 5. Cleaning energy was found to have a major effect on pressure drop performance, but cleaning frequency registered an insignificant effect within the 6 to 20 minute range studied. Among fabrics, a new combination felted fabric, composed of Teflon and glass, showed excellent performance and stability under a long bag life.		
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ABSTRACT

A program was performed to evaluate a number of fabric filter operational alternatives in baghouses controlling particulate emissions from industrial coal-fired stoker boilers. Two simultaneous evaluations explored various techniques to achieve higher gas-to-cloth ratios and longer bag life.

It was found that off-line, high energy, pulse jet cleaning was necessary for long term pressure drop stability at G/C ratios $>5/1$.

Cleaning energy dramatically affected pressure drop performance, but cleaning frequency had only a minor effect when varied from 6-20 minutes.

A felted fabric combination of Teflon and glass exhibited excellent performance, life, and stability.

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I. INTRODUCTION

This project was an extension of a series of programs funded by the EPA Industrial Environmental Research Laboratory (now Air and Energy Engineering Research Laboratory) for the application of fabric filters to industrial coal-fired stoker boilers.

The initial program, conducted from 1973-1976, was a pilot plant project to screen potential fabric candidates and determine the applicability of fabric filtration to this process. Reports summarizing this effort can be found in EPA-650/2-74-058,7/74¹, and EPA-650/2-74-058a,8/75². A full scale program was then conducted from 3/76 through 2/79 and continued at a second site from 12/79 through 12/80. A report summarizing this effort can be found in EPA-600/7-79-094,4/79³.

The above pilot and full scale programs clearly showed that fabric filters could be successfully applied to industrial coal-fired stoker boilers but that it was not a simple application compared to others such as rock dust, wood dust, iron and steel processes, etc. The prior programs and full scale experience at many other sites have shown this application to be relatively difficult and subject to a wide range of inlet conditions which are potentially damaging resulting in lower flow capability and shorter bag life.

Two parameters which dramatically affect the technical and economic performance of a fabric filter system, gas/cloth ratio

(G/C) and bag life needed further definition and improvement. In March, 1981, this program was established to evaluate techniques for achieving higher G/C ratios and longer bag life while meeting required emission levels. Higher G/C ratios would lower capital costs by permitting a smaller baghouse while longer bag life would reduce operating costs. This report covers evaluations conducted between March, 1981 and November, 1982, plus fabric test results on bags removed during May, 1983.

This contract was funded by EPA with Fabrics America, Inc. serving as the prime contractor and supplying the site, and ETS, Inc. serving as the sole subcontractor and performing all technical tasks. The evaluations were conducted on two modified Enviro Systems and Research baghouses located at the Kerr Finishing Plant in Travelers Rest, South Carolina. Figure 1 shows the general site layout.

Two separate evaluations were performed. A study of methods to increase G/C ratio was conducted in Baghouse #1, which was controlling emissions from boiler #5. A study of various fabrics for flow and strength retention was conducted in Baghouse #2, which controlled emissions from a bank of small boilers, #1-4. Detailed descriptions of the boilers and baghouses are provided in a later section. In general, house #1 was similar to a modern day, six module pulse jet collector with both on-line or off-line cleaning mode capability. House #2, while employing caged bags and outside-in filtration, did not utilize high pressure pulses

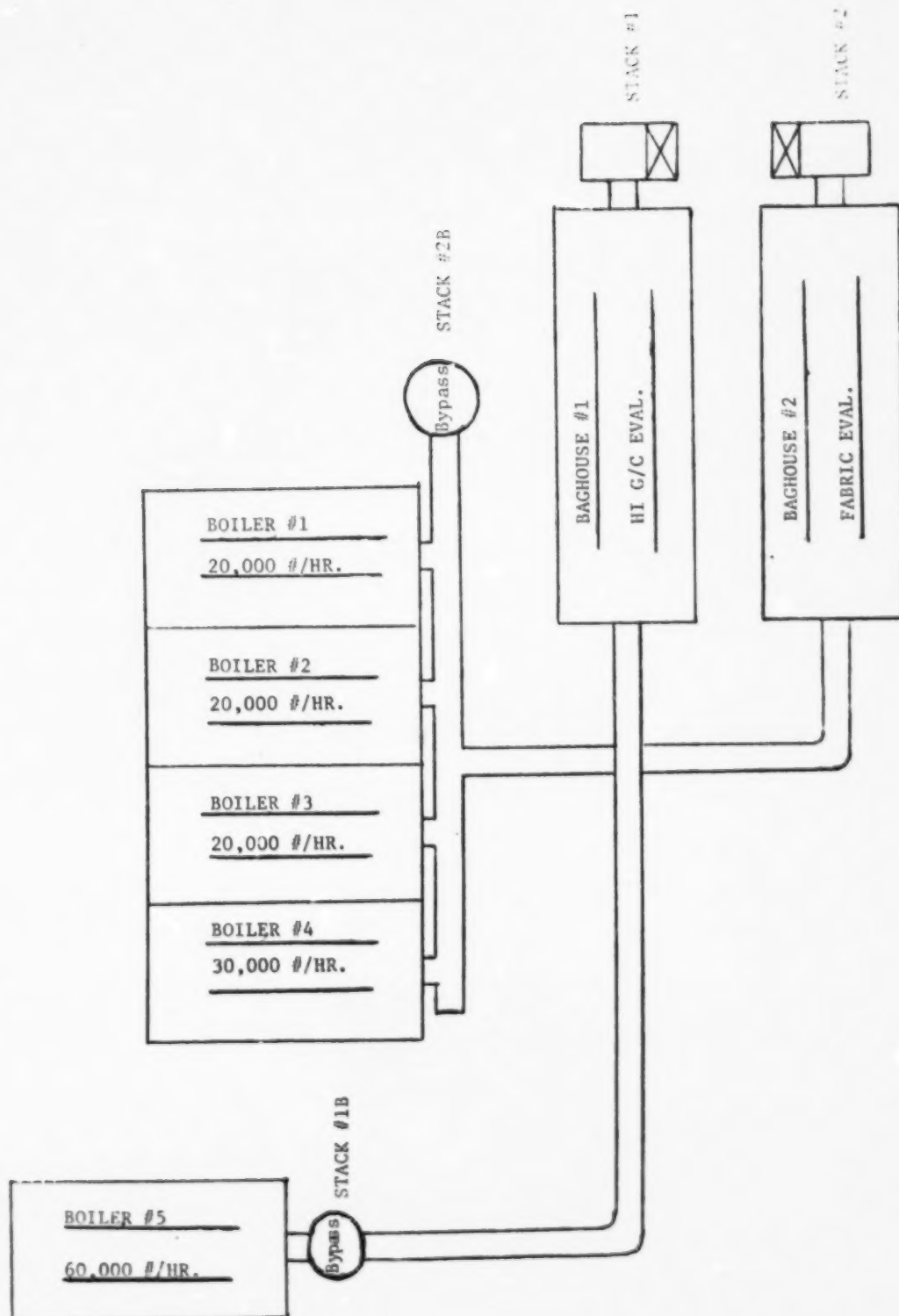


Figure 1. Kerr Site Layout

for cleaning but rather low pressure (<10" w.g.), high volume, reverse-flush type cleaning. This produced a lower cleaning energy than the pulse jet but higher than conventional reverse-air cleaning and had been used successfully in several other applications, such as quarries and woodworking, where cleaning energy requirements were low to moderate.

The boilers produced steam for a textile finishing plant and load requirements fluctuated often and rapidly. Because of this, gas flow and dust loading to the baghouses fluctuated significantly. To better compare different evaluations over time, the fabric drag (fabric ΔP divided by G/C) was determined and each evaluation repeated several times.

II. CONCLUSIONS

A) High G/C Study

1) Pulse-jet cleaning is necessary for any long term pressure drop stability at G/C ratios higher than 4/1 when employing felted fabric. G/C levels up to 5/1 were run in Baghouse #2 on an intermittent basis but, with fabric drags approaching 2, would produce 10" plus pressure drop. Although not well documented due to constantly varying loads, it is not believed that woven fabrics could be stably run above 4/1 on a steady-state basis either.

2) The amount of cleaning energy delivered to the bags had a dramatic impact on fabric drag. An increase of 50% energy

decreased the drag by 1/3. The amount of cleaning energy delivered to a bag is dependent on the pulse pressure, valve size, number of bags per valve and other pulse system parameters. It would appear that design of the pulse system should be conservative and provide for maximum flexibility in controlling the delivered pulse energy.

3) Off-line cleaning is required for stable operation with G/C ratios above 5/1. Re-entrainment of dust following cleaning in an on-line mode produced residual pressure drop creep resulting in pressure drop runaway and flow limitation. Obviously, the particle size distribution of the incoming dust and the specific collector velocities can affect the degree of re-entrainment that will occur, but experience at this location confirms findings at other stoker boiler installations. It is recommended that only systems capable of off-line cleaning be employed for this application.

4) Cleaning frequency had only a minor impact on fabric drag when varied from six minutes to twenty minutes.

5) Fabric construction can have a dramatic impact on fabric drag. Various constructions of Teflon felt were evaluated. A blend of Teflon and glass fibers, which had shown promise of improved flow capability in lab testing, performed very well throughout the test period. Fabric drags of typically less than

1.0 were demonstrated at G/C ratios of 7-9, and with stable pressure drops.

B) Fabric Life Study

1) The potential cyclic nature of this application requires the use of fabrics that can survive multiple start-up and shutdown cycles with their resultant acid dew point excursions.

2) Woven glass bags with either 10% Teflon B or acid resistant finish exhibited a two-year-plus bag life in the low cleaning energy baghouse. The impact of high energy pulse jet action on woven glass was not studied. Significant failures began occurring after two year exposure.

3) A special experimental Teflon finish showed initial strength retention superiority over the other finishes applied to woven glass, but this advantage appeared to go away within one year of exposure.

4) Nomex is not a candidate fiber for this application due to its inability to withstand the SO₃ and sulfuric acid inherent in both normal operation and dew point excursions.

5) Teflon felt is a very durable fabric. A section of original bags, installed in January, 1977, were still functioning after five years of operation.

III. RECOMMENDATIONS

Pulse jet collectors used on this application should be designed for off-line cleaning and net G/C ratios less than 5/1 with conventional fabrics. New fabrics with promise of higher flow capability appear ready for commercial introduction and should be considered.

IV. SYSTEMS DESCRIPTION

1.0) System #1

The No. 1 baghouse, at the time of this study, was applied to a coal-fired Babcock and Wilcox boiler rated at 60,000 lbs. of steam per hour. A stoker grade coal (1 1/2 in. x 1/4 in.) was fed to a spreader type Detroit Rotostoker from a central weighing scale manufactured by Richardson into three (3) stoker sections and onto a riser type dump grate. The design steam pressure was 250 lbs. per sq. in. gauge at saturation temperature with a feedwater temperature of 214°F from a mixing drum supplied by make-up water and steam returned lines. Normal maximum boiler operation provided 52,000 lbs/hr steam at 160 psig and saturation temperature.

A Western Precipitator Corporation type 9VSR12, Model P59205B multicyclone was located on the boiler outlet but no economizer or flyash reinjection was provided. Instrumentation for automatic combustion control was provided and normal operation produced flue gas characteristic of 400-450°F and 25-40,000 ACFM. The combustion air flow was provided by a combination of

forced draft, overfire air, and induced draft fans. Ash handling was a manual labor process in which employees raked the ash out from underneath the boiler grates, loaded it into wheelbarrows and dumped it into the yards.

2.0) System #2

The No. 2 baghouse was applied to a bank of four coal-fired boilers manifolded into a 200 ft. natural draft stack.

The first three boilers were constructed in 1928 by Walsh and Weidner Boiler Co., and were equipped with Combustion Engineering underfeed retort spreader type stokers and side dump grates. The boilers were rated at 22,500 lbs/hr of steam at 250 psig and saturation temperature. The fourth boiler was constructed by Combustion Engineering in 1941 and was a sterling type equipped with a Combustion Engineering underfeed retort spreader type stoker and side dump grates. The steam flow rating was 30,000 lbs/hr at 250 psig and saturation temperature. All four boilers were provided with forced draft fans and normally operated two at a time providing steam at 160 psig and saturation temperature. The stoker size (1 1/2 in. x 1/4 in) coal was fed to the stokers from the central weighing scales.

Outlet flue gas was directed to the baghouse from the boiler bank stack manifold at approximately 400-450°F and 25-35,000 ACFM with two boilers operating.

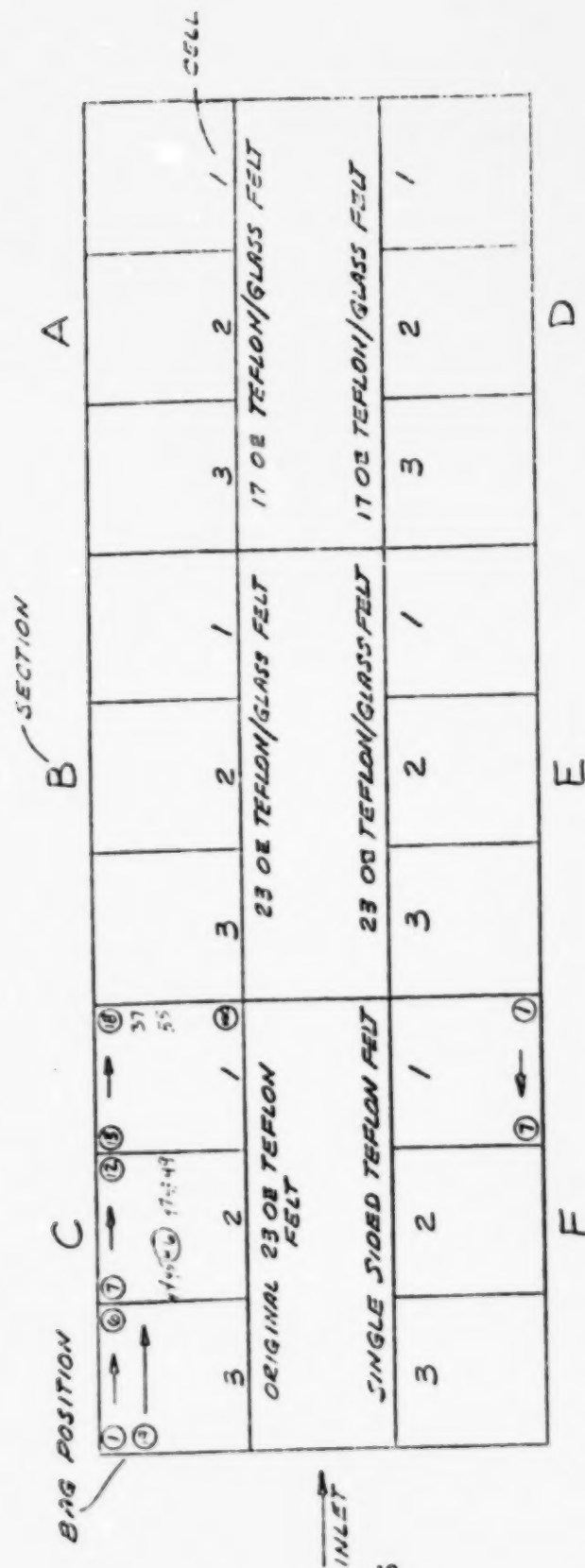
Ash handling was a manual labor process, as described in System #1 above.

3.0) System #1 - Baghouse Description

The baghouse was a modified Enviro-Systems and Research Model RAC-III. This collector housed 648, 5'0" x 104" long bags providing a total cloth area of 6,800 sq. ft. The bags were top loaded, snapped into the tubesheet and utilized ten stringer wire-formed cages. The cleaning energy was supplied by 80-100 psi compressed air pulses assisted by low-pressure reverse-flushing air. The original design had 18 separate bag plenums and outlet dampers, but with common inlet and hopper areas. This provided a semi-off-line cleaning mode, but not of the type seen in today's modular collectors. It also lacked the ability to monitor and control the flow through each section. Modifications were performed to sectionalize the inlet and hoppers into six sections. See Figures 2 and 3. Sectional inlet dampers, test ports, flow monitors, and differential pressure (ΔP) manometers permitted the control and monitoring of the gas flow into each section. The resultant system provided a high degree of cleaning mode flexibility. Cleaning could be on-line, pulse jet only; on-line, pulse jet with varying amounts of reverse-flush assist; or off-line variations of the above. Normal operation was to take an individual cell off-line by closing the outlet damper and allowing a minimum volume of reverse gas to flow, primarily to block the forward leakage flow and pulse the bags. This most

KERR BAG - CELL SCHEMATIC (SYSTEM 1)

FIGURE 2



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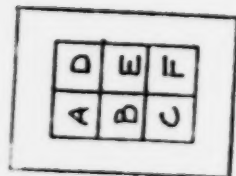


Figure 3 Kerr Finishing Fabric Filters
System Schematic

Test Point Locations of Both
Houses

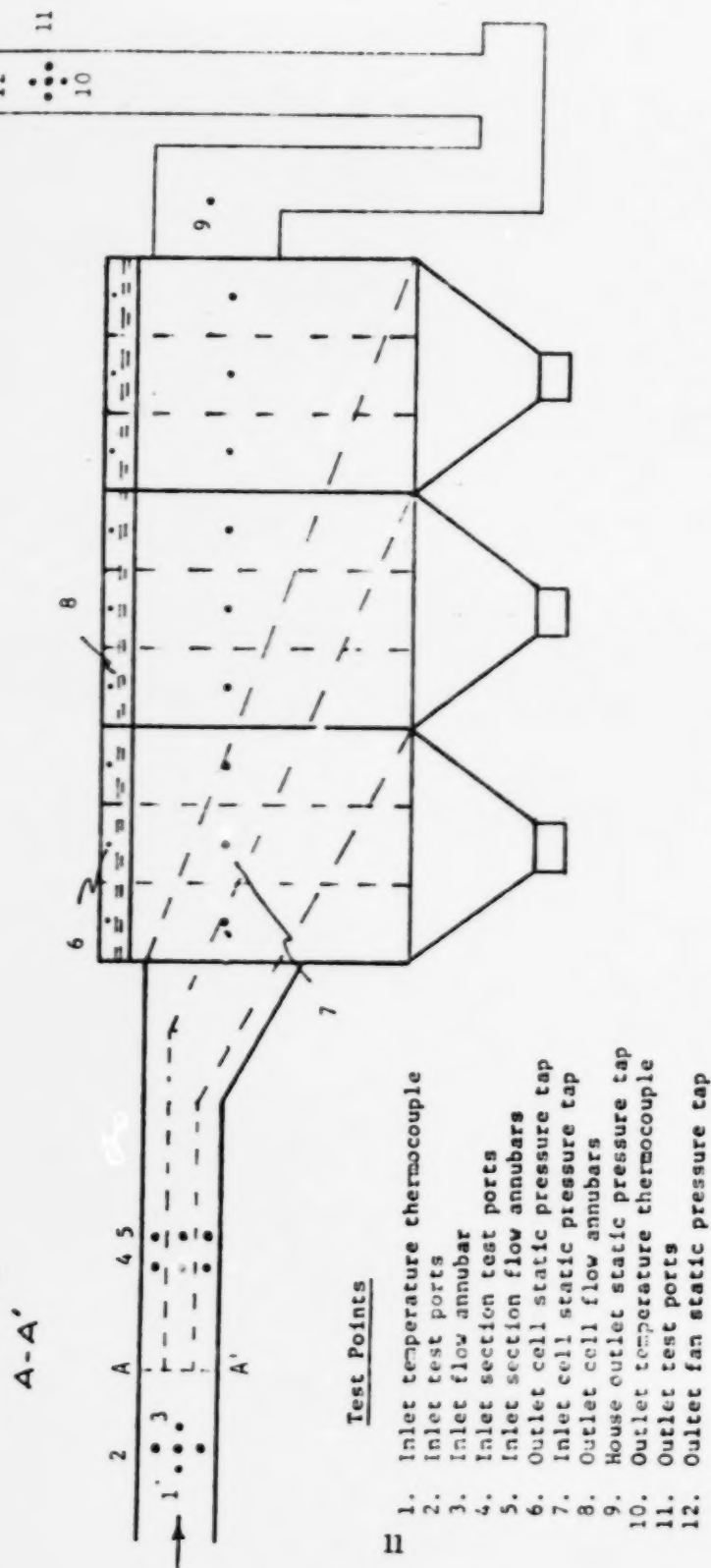


TABLE 1. BAG AND FABRIC DESCRIPTION

Description Baghouse Section ^a	Fabric [®] (Teflon)	Wt. oz/yd ²	Perm fpm	Mullen Burst psi	Tensile St. lbs/in Width		Bag Size dia. X length, in.	Initial Installation Date
					Warp	Fill		
A ^b	Exp. (Y1)	21	36	354	87	78	5½ x 108	10/81
B	Exp. (X)	23	21	340	88	70.5	5½ x 108	07/81
C	XT 2363 (Std)	23	27	306	115	93	4-7/8 x 108	01/77
D	Exp. (Y2)	19	42	324	84	74	5½ x 108	10/81
E	Exp. (X)	23	21	340	88	70.5	5½ x 108	07/81
F	Exp. (Asym)	17	59	231	83	61	5½ x 108	05/81

^a Location of section shown in Figure^b This fabric is very similar to TEFAIR Fabric currently being marketed by DuPont.

closely simulates today's modular off-line cleaning pulse jet collectors.

4.0) Fabric Description - Baghouse 1

All fabric in Baghouse No. 1 was a form of Teflon [®] fiber felt, supplied by the E. I. duPont de Nemours Company. A description of the fabric and bags utilized is given in Table 1. Sections A, B, D, and E contained bag sets of experimental Teflon [®] fiber felt of varying weights and construction. Section C contained existing bags from the prior EPA program. Section F contained bags that were constructed in an asymmetrical manner, such that most of the felt was on the outside of the bag. A characteristic of Teflon [®] is that it physically shrinks with increasing temperature. This resulted in not only a smaller bag, but also a lower in-use permeability, as shown in Figure 4. Heat setting at sufficient time and temperature can minimize this problem; however, these characteristics must be accounted for in the initial fabric and bag specifications. Note that the original Teflon [®] bags were not oversized as much as the newer bags (4-7/8 in. diameter versus 5-1/4 in.). This was due to a lack of understanding of the actual shrinkage rate at the time (in 1976) that these bags were constructed. A graph of permeability vs. temperature for the various fabric styles can be seen in Figure 4. Unfortunately, all of these fabric styles were not obtainable at the beginning of the test program; they were installed as they became available. The installation dates are included in Table 1.

PERMEABILITY VS. TEMP.
FOR FELTS AT KERS

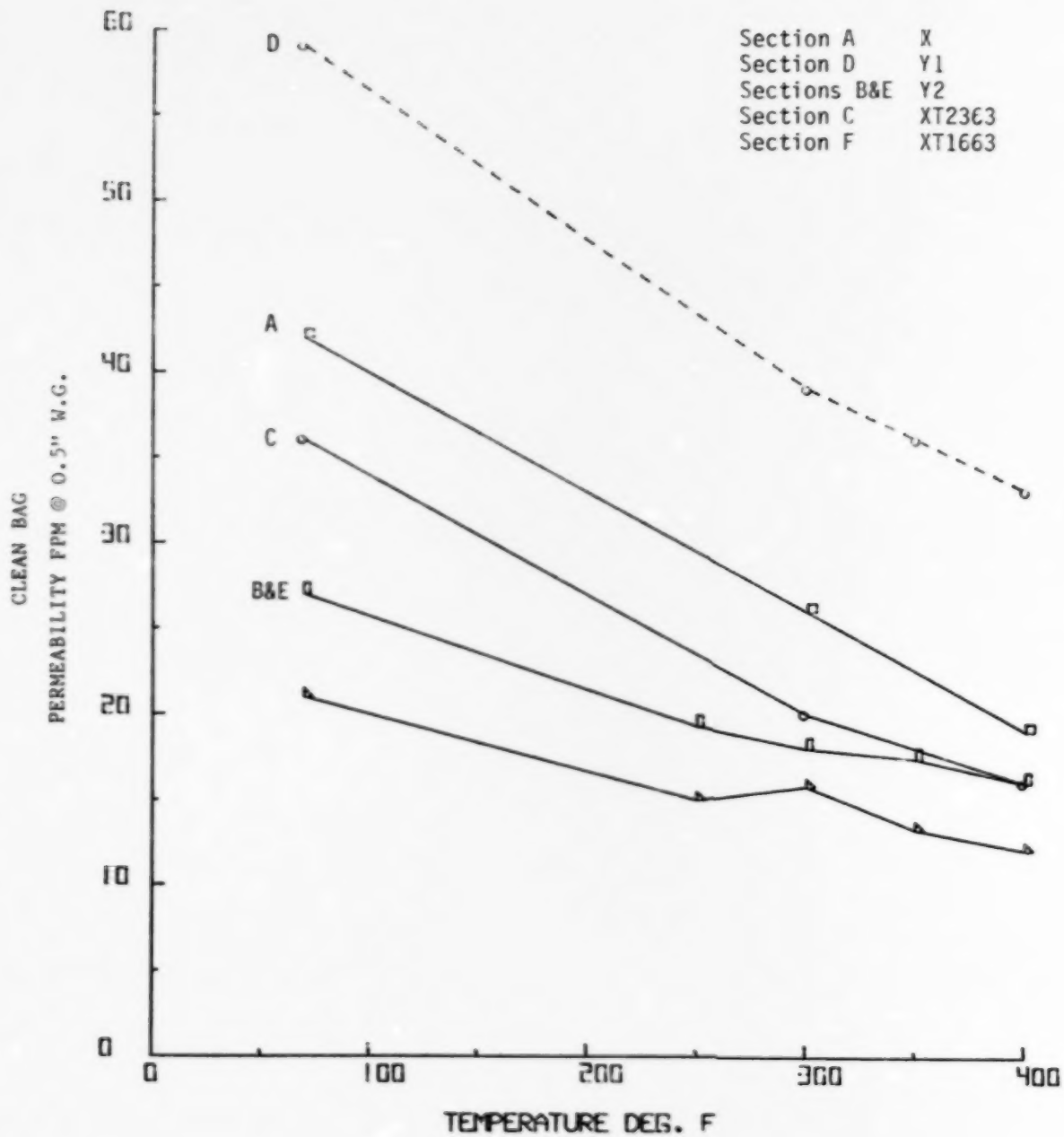


Figure 4 Permeability VS Temperature

5.0) System 2 - Baghouse Description

The No. 2 baghouse was identical to No. 1, except its cleaning method was reverse air plenum pulse instead of pulse jet. The collector had 648 bags with a nominal size of 5 in. diameter and 104 in. length, having a total cloth area of 6,800 sq. ft. Normal filtering velocity was 4-5 fpm. Its cleaning energy was supplied by a 4,000 acfm fan at 10 in. w.g. pressure through cell outlet poppet dampers that simultaneously stopped the normal forward gas flow through one cell, and introduced the reverse pulse of heated ambient air. A typical cleaning cycle was 10 seconds of delay before moving to the next cell. This produced a bag cleaning frequency of 4.5 minutes. The house was divided into six sections and was instrumented in the same manner as house No. 1.

6.0) Fabric Description - Baghouse 2

The fabric being evaluated consisted of four bag sets: three woven glass with varying finishes and one Nomex® felt with an acid resistant finish. The woven glass bags all had the same basic fabric construction, one that is presently being used in both pulse jet and reverse air collectors on coal-fired boilers. Three different finishes were being evaluated on the glass bags: an experimental Teflon® based finish developed by duPont, and

® Dupont TFE Fluorocarbon fiber

two state-of-the-art finishes, Burlington's style I615, 10% Teflon B[®], and Burlington's style I625, Acid Flex[®]. The Nomex[®] bag set utilized Globe Albany's 16 oz. Nomex[®] felt with Permagard[®] finish that has shown success in Europe.

Fabric specifications are given in Table 2. The locations of the various fabrics in the baghouse are shown in Figure 5. A test cell incorporating all fabric types was established to normalize any biased effects of section location.

V. RESULTS AND DISCUSSION

A) High G/C Study

1.0) Technical Objectives:

The program's primary objective was to develop methods of raising the filtering velocity operating level and, after demonstrating stability, define the effect on drag, efficiency, and bag life. The mechanisms evaluated for raising the G/C ratio were:

- Cleaning energy; i.e., pulse jet versus reverse air versus combinations;
- Cleaning mode: on-line versus off-line;
- Cleaning frequency; and
- Fabric type and style.

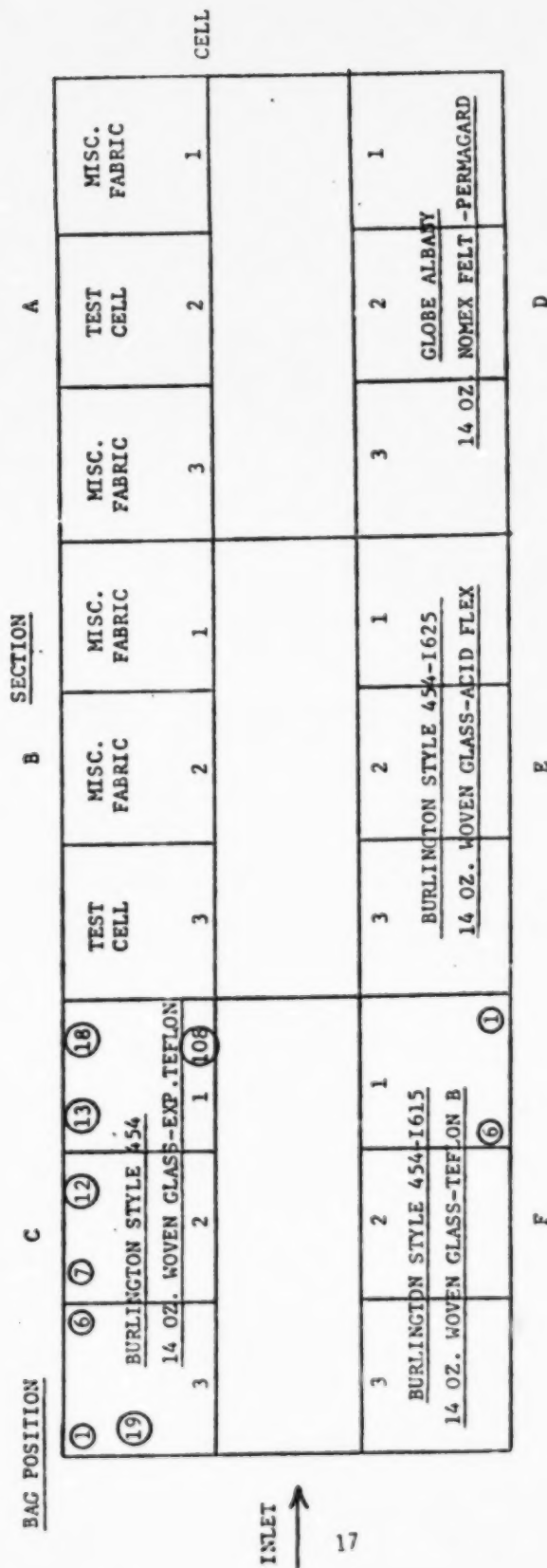


Figure 5. Kerr Baghouse - cell schematic - system 2.

TABLE 2

WOVEN GLASS FABRIC ANALYSIS

ALL FABRICS

Fiber: Glass

Construction:

Weave 3 X 1 Twill

Count W44 X F24

Warp Yarn DE 37-1/0 - (Singles Construction)

Fill Yarn DE 75-1/0 - (Plied, 2 Texturized, 1 Untexturized)

Virgin Cloth Perm $\approx$ 90 fpm @ 0.5 in. W.G.

	A, Acid Flex [®]	B, Teflon B [®]	X, Exp'tal
Fabric Finisher	<u>Burlington</u>	<u>Burlington</u>	<u>Clark-Swabel</u>
Perm, Avg.	77.8	56.1	47.5
LOI, wt%	4.6	9.5	9.6
Oz/yd ²			
- Treated	12.6	14.3	13.6
- Untreated	12.0	12.9	12.3
Thickness, in.	0.0144	0.0142	0.0158
Virgin Cloth Perm $\approx$ 90 fpm			

2.0) Parameters Monitored and Approach

The following describes the evaluation methods employed and the parameters monitored.

2.1) Section Drag:

The parameter used to define stable operation was average section drag, which is the average tubesheet ΔP during a filtering cycle, divided by the section G/C:

$$S \text{ (Avg)} = \frac{\Delta P \text{ (Avg)}}{G/C}$$

A section was defined as having short term stability if no consistent upward movement in the average drag was observed over a minimum 2-3 day evaluation period.

The three cells of each section had pressure taps, so all 18 cells of the baghouse could be monitored for pressure drop. Generally, the middle section was monitored, and the ΔP was registered on a 15 in. w.g. Magnehelic gauge. There was one Magnehelic for each section. The G/C ratio was monitored by an Annubar located at each section inlet, and the flow was registered on an inclined manometer. The instruments were located on a panel at the inlet test level.

The initial evaluation approach was to establish the cleaning variable to be tested, adjust each section inlet damper to produce equal section G/C, and monitor section ΔP . A method which proved more reliable was to adjust for equal section ΔP

and monitor section flows. Since the total gas volume fluctuated with steam load demand, the average G/C typically varied between 5 and 8. The drag values were recorded several times each day. Each condition was evaluated long enough to establish only short term stability or instability. At various times during the test program, snapshots of ΔP versus G/C were obtained by varying the G/C from 6 to 10 for short periods and monitoring ΔP . This aided in verifying long term data, and also gave a profile of fabric drag versus exposure time.

2.2) Efficiency

Collection efficiency was determined at regular intervals during the program. Due to the common outlet, testing of individual sections required taking all other sections off-line. This proved difficult and provided questionable results. Due to budget constraints, additional testing was deferred. No individual fabric emission testing was done. Both baghouses were tested with all sections active and have met compliance.

3.0) Results and Conclusions

Time and funds dictated a fairly rapid initial evaluation of the magnitude of the effects of the variables. Having the fabrics enter the evaluation at different times further complicated the program; however, certain trends were consistently found.

3.1) Effect of Cleaning Energy on Fabric Drag

The original baghouse utilized two 1 1/2 in. diameter pulse jet valves per cell to pulse 18 bags each. In order to achieve the higher G/C desired without incurring high damper pressure drop losses, bags were removed as shown in Figure 6. Since all active bags were not located in four rows per cell, the cleaning energy supplied to each bag could easily be increased by 50% by removing one blow pipe per valve. The operating mode with four pipes is referred to as the High Pulse jet mode, and with six pipes, the Medium Pulse Jet mode. A much lower level of cleaning energy was achieved by eliminating the pulse jet and cleaning with reverse air only.

Table 3 shows the relative drag values observed during the three energy levels. A significant effect was seen on all fabric types.

TABLE 3. EFFECT OF CLEANING ENERGY ON FABRIC DRAG

Fabric Type	R.A. Only	Typical Drag	
		Med. P.J.	High P.J.
Std. Teflon ®	Unstable	1.5	1.0
Asym. Teflon ®	Unstable	1.2	0.8
Exp. Teflon ®	1.1	0.8	0.5

The experimental felts are grouped as shown, since no significant difference was observed between styles during this experiment. Note that both the standard and asymmetrical felts did not produce a stable operating point with reverse air only. This may have been due to their longer bag set exposure or differences in construction.

3.2) Effect of Cleaning Mode on Fabric Drag

Off-line cleaning was accomplished by closing a cell's outlet damper to block the forward gas flow, pulsing all the bags in that cell at one time, and keeping the cell off-line for 15 seconds before reopening the outlet damper and resuming normal flow. On-line cleaning was done by allowing the pulse jet cleaning to continue with the outlet dampers open. High energy cleaning was employed throughout this experiment.

Table 4 shows the relative drag values observed during the two cleaning modes and at high and low filtering velocities.

Table 4. EFFECT OF CLEANING MODE ON FABRIC DRAG

<u>G/C Ratio</u>	<u>Typical Drag</u>			
	< 5		> 6	
<u>Cleaning Mode</u>	<u>Off-Line</u>	<u>On-Line</u>	<u>Off-Line</u>	<u>On-Line</u>
<u>Fabric Type</u>				
Std. Teflon®	1.0	1.0	1.0	1.5 (Unstable)
Asym. Teflon®	0.8	1.0	0.8	1.5 (Unstable)
Exp. Teflon®	0.5	1.0	0.5	1.2 (Unstable)

This evaluation confirmed past operating experience at Kerr in that stable operation at high G/C and with on-line cleaning was not possible. The low G/C evaluation was not run over a long enough time to determine if long term stability could be maintained. The dramatic effect on drag is assumed to be due to the reduction of re-entrainment in the off-line mode.

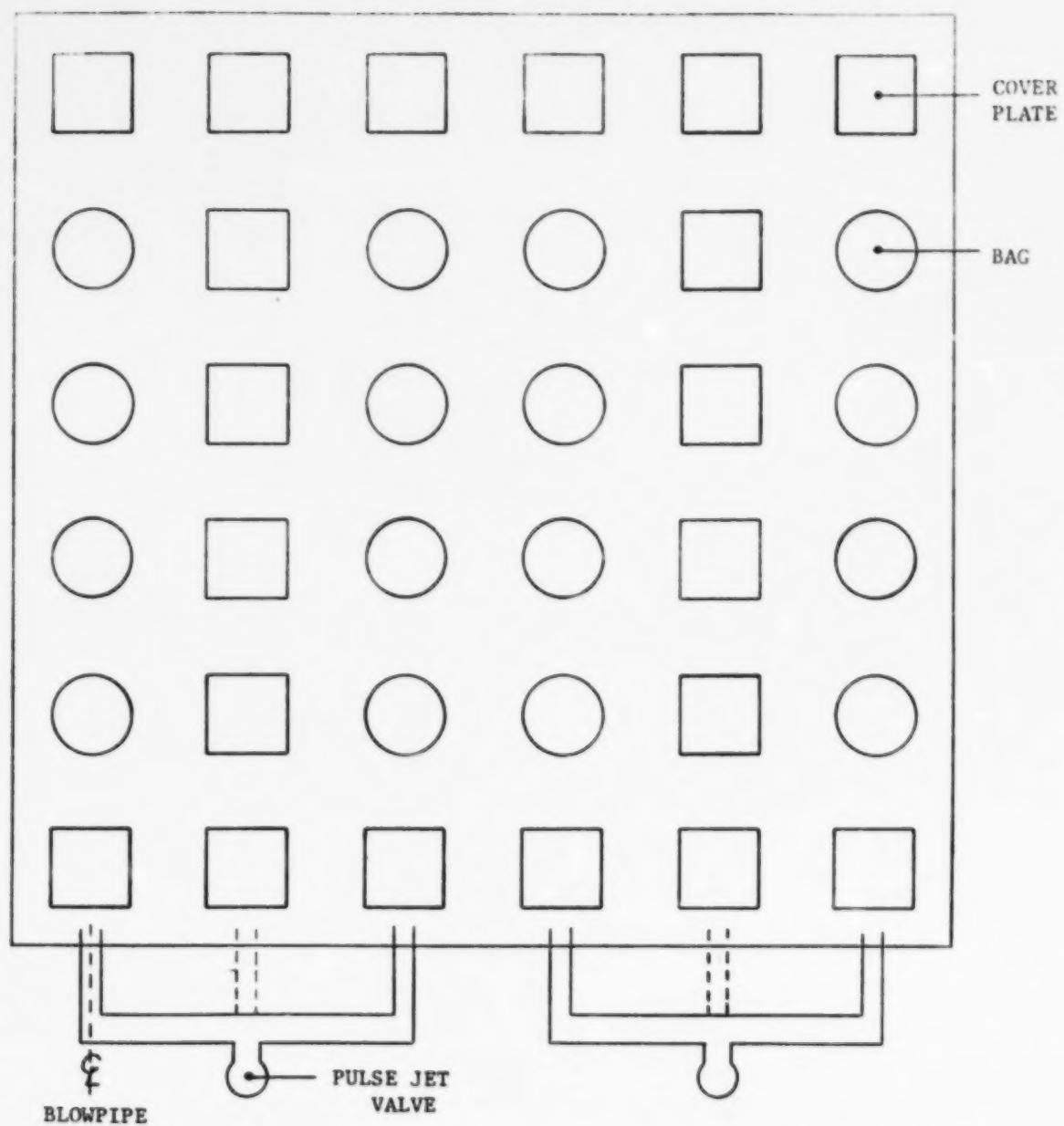


Figure 6. High Gas-To-Cloth Cell Bag Layout

3.3) Effect of Cleaning Frequency on Fabric Drag

Theoretically, one tries to establish cleaning frequency at the minimum level that produces a reasonable stable pressure drop. This then should minimize compressed air usage and extend bag, pulse jet, and damper component life. Prior experience with the standard Teflon ® felt and asymmetric felt was that a 6-minute cleaning frequency was required with the medium cleaning energy level: most data with those fabrics were at that cleaning frequency. Initial evaluation of the new experimental fabrics indicated that a lower cleaning frequency could be used: most data on those fabrics were collected at the 20-minute cleaning frequency. With all sections employing high energy cleaning, the results of Table 5 were obtained.

TABLE 5. EFFECT OF CLEANING FREQUENCY ON FABRIC DRAG

Cleaning Frequency Fabric Type	Typical Drag	
	6 Min.	20 Min.
Std. Teflon ®	1.0	1.2
Asym. Teflon ®	0.8	1.0
Exp. Teflon ®	0.5	0.5

Note that the fabric drag was not reduced by increasing the cleaning frequency on the experimental felts. The pressure drop rise between cleanings was both very low and extremely linear, indicating the possibility of further extending the cleaning frequency. The short term increase in fabric drag of the standard and asymmetric felts under high cleaning energy and 20-minute cleaning was quite modest. Note that test duration was not long enough to verify long term stability and that the more

rapid rise of pressure between cleaning indicates that the optimum cleaning frequency may be somewhere between 6 and 20 minutes.

3.4) Effect of Fabric Construction on Fabric Drag

Due to the variables of bag history, cleaning energy, and cleaning cycles employed, direct comparisons of the various Teflon[®] felt constructions are difficult. Earlier tables have shown the Teflon[®] styles for reference to indicate the relative effect of the cleaning variable under study. The indicated trends are both real and significant.

Table 6 provides relative drag values for the four major felt constructions that were evaluated. Experimental construction X differed from construction Y in that Y was designed to have a 50% higher initial permeability. Two different weight bags of construction Y were fabricated (Styles No. 402 and 403). No significant difference was seen between the two in the drag results.

TABLE 6. EFFECT OF FABRIC TYPE ON FABRIC DRAG (short term evaluation)

<u>Inlet Loading (gr/acf)</u>	<u>Typical Drag</u>	
	<u>0.2 - 0.3</u>	<u>0.5 - 0.8</u>
Std. Felt	1.0	1.6
Asym. Felt	0.8	1.4
Exp. Construction X	0.5	1.1
Exp. Construction Y	0.5	0.8

All of the prior evaluations were run with the system inlet having a high degree of dilution due to ambient air in-leakage in the boiler stack, expansion joints, and emergency dilution damper. This produced an inlet grain loading of approximately 0.2 gr/acf. For this study, the in-leakage was minimized through most of these areas. While this reduced the average G/C, the boiler load fluctuated sufficiently over the course of a day that the same G/C range of 6 to 10 could still be evaluated with the reduced cloth area. Also, boiler operation produced some variation in grain loading, with some data being obtained at 0.5 to 0.8 gr/acf. The short term ΔP versus G/C evaluations showed a constant drag over this range.

The drag data previously shown were a result of short term evaluations which did not allow full stabilization of fabric condition and were intended only for relative comparisons of fabric types. From May to August, 1982, an evaluation at fixed conditions revealed the results contained in Table 6. While these drags were higher than previously reported, they were consistent under normal boiler operation and represent what might typically be expected. To further evaluate the drag values, the system was operated at relatively constant conditions and modes over an extended period of time. The baghouse was operated with the stack cap bypass damper closed; the Vortex damper control on automatic; off-line cleaning; a cleaning frequency of 6 minutes; and a typical grain loading of 0.5 to 0.6 gr/acf. This evaluation produced the data of Table 7.

TABLE 7. EFFECT OF FABRIC TYPE ON FABRIC DRAG (long term evaluation)

Fabric Type	Typical Drag
Standard Felt	1.6 - 1.7
Asym. Felt *	--
Exp. Teflon Const. X	0.95 - 1.0
Exp. Teflon Const. Y1	0.9 - 0.95
Exp. Teflon Const. Y2	1.1 - 1.2

4.0) Conclusions as to High G/C Capability

The primary thrust of the evaluation was to identify parameters that produce lower drag values or improve pressure drop stability so that higher G/C levels could be achieved with reasonable and stable pressure drops. By necessity, the G/C levels varied with the boiler load, and specific evaluations were short.

The results to date indicate that the optimum system operation is with higher energy, off-line pulse jet cleaning, a cleaning frequency of 6-20 minutes, and experimental Teflon® felt Construction Y. Short term stability up to a G/C of 10 was demonstrated. During the long term evaluation, the system was operated in a manner that allowed the section pressure drops to self balance and the section gas volume flows to be dictated by their fabric drags. This resulted in the experimental felt Construction Y running typically at 7-9 G/C with no instability observed and a drag typically less than 1.0, even at the highest inlet grain loadings during high boiler loads.

A longer term evaluation of the above conditions is recommended and, if successful, could double the present filtering velocity now common in this application.

B) Fabric Evaluation Program

1.0) Technical Objective

This program's primary objective was to evaluate the operational characteristics and service life of the various fabrics while exposed to normal operating conditions of a coal-fired boiler and baghouse system.

2.0) Parameters Monitored and Approach

The following describe the evaluation methods employed and the parameters monitored.

2.1) Fabric Drag

Filtering velocities were equalized as much as possible between test sections throughout the evaluation by monitoring the inlet Annubars and manually adjusting the section inlet dampers. Normal filtering velocities were maintained in the 4-5 fpm range. Section tubesheet ΔP was recorded daily to compute average fabric drag values. Fabric permeability was monitored on bags that were periodically removed for testing.

2.2) Fabric Properties

To evaluate the effect of operational exposure on bag life, the fabric strength characteristics were monitored. Test bags were scheduled for removal after exposure times of 1 hour, 1 day, 1 week, 1 month, 3 months, 5 months, and 7 months. Fabric testing included Tensile, Mullen Burst, MIT Flex, Loss on Ignition (LOI), and visual and microscopic inspection.

2.3) Efficiency Testing

Mass efficiency tests by EPA Method 5 and individual section emission testing to provide comparative data between fabric types were not done due to budget constraints.

3.0) Bag Conditioning and Operating History

Conditioning of the bags was initiated on May 14, 1981, and continued for the next four weeks. The flow was maintained at the low (1.5 - 2.5) G/C for an extended time to both obtain some data at low G/C and ensure that system control would prevent biasing of any fabric. The flow, temperature, and section pressure drop were carefully monitored, and the bags were inspected visually.

Due to intermittent boiler operation and long weekend shutdowns, seven full days of exposure required one month of calendar time (early in the program). The plant was then shut down for the month of July. After resuming operation, the baghouse was set to operate at four to five fpm. Malfunctions in the damper system of Section C, the experimental Teflon® finish, resulted in lower filtering rates in that section for three weeks. Again, due to limited plant production which reduced the boiler needs, it required approximately three months to obtain the next two months exposure time. The three month test bags were scheduled for removal on October 16. Unfortunately, a severe boiler upset caused a fire in the baghouse, and all the experimental Teflon® finished bags and this test bag cell were

destroyed on October 1. The baghouse remained off-line until new experimental Teflon ® finish bags could be obtained. The evaluation was restarted on May 5, 1982.

4.0) Results and Observations

The cyclic nature of the baghouse during this evaluation dramatized the need for fabrics that could survive many start-ups, shutdowns, and their resultant dew point excursions. Normal boiler operation was started up on the 2nd shift Sunday, and shut down on the 2nd shift Friday. Due to production limitations, several shorter operating cycles were run. In addition, baghouse auxiliary component malfunctions forced the baghouse off-line at times. Needless to say, this type of application intensified the need for preheat and purge capabilities (which existed) and fabrics that could resist acid condensation.

4.1) ΔP Evaluation

Through June 25, the plant's summer shutdown, the filtering velocities were held constant, and for all practical purposes, the ΔP levels of all sections were the same. Following the shutdown, Section C (exp. finish) ran at lower G/C ratios and higher ΔP levels as a result of cleaning system problems. These problems were intermittent, recurring throughout August. After correction, its ΔP was comparable to that of the other section.

No significant differences in fabric drag could be seen during the evaluation between sections. Average drags ranged from 1.5 to 2.0, reflecting the low energy cleaning system being employed.

4.2) Fabric Strength Tests

Fabric test results are summarized in Table 8 and plotted on Figures 5 through 8. The test plan called for the removal of three bags of each type after 1 hour, 24 hours, 1 week, 1 month, 3 months, 5 months, and 7 months of exposure time. After removal, the top, middle, and bottom of each bag was tested for its strength characteristics. The tests included permeability, tensile strength, flex strength, and burst strength. Tests were completed through 7 months of exposure. In addition, all but the experimental bags had over 6 months additional off-line exposure. It was determined that there were no significant differences in the strength characteristics of the top, middle, and bottom of any of the bags. Note that increases in the value of a given parameter versus on-line time were not expected. These increases are attributable to variations in the initial strength characteristics of the bags, finish protection effectiveness, bag location, or (in the case of permeability) handling.

The new, 1 hour, 24 hour, 1 week, and 1 month Acid Flex ®, Teflon B ®, and Nomex ® data were obtained before the October 12 fire. The three month data were obtained from bags off-line for

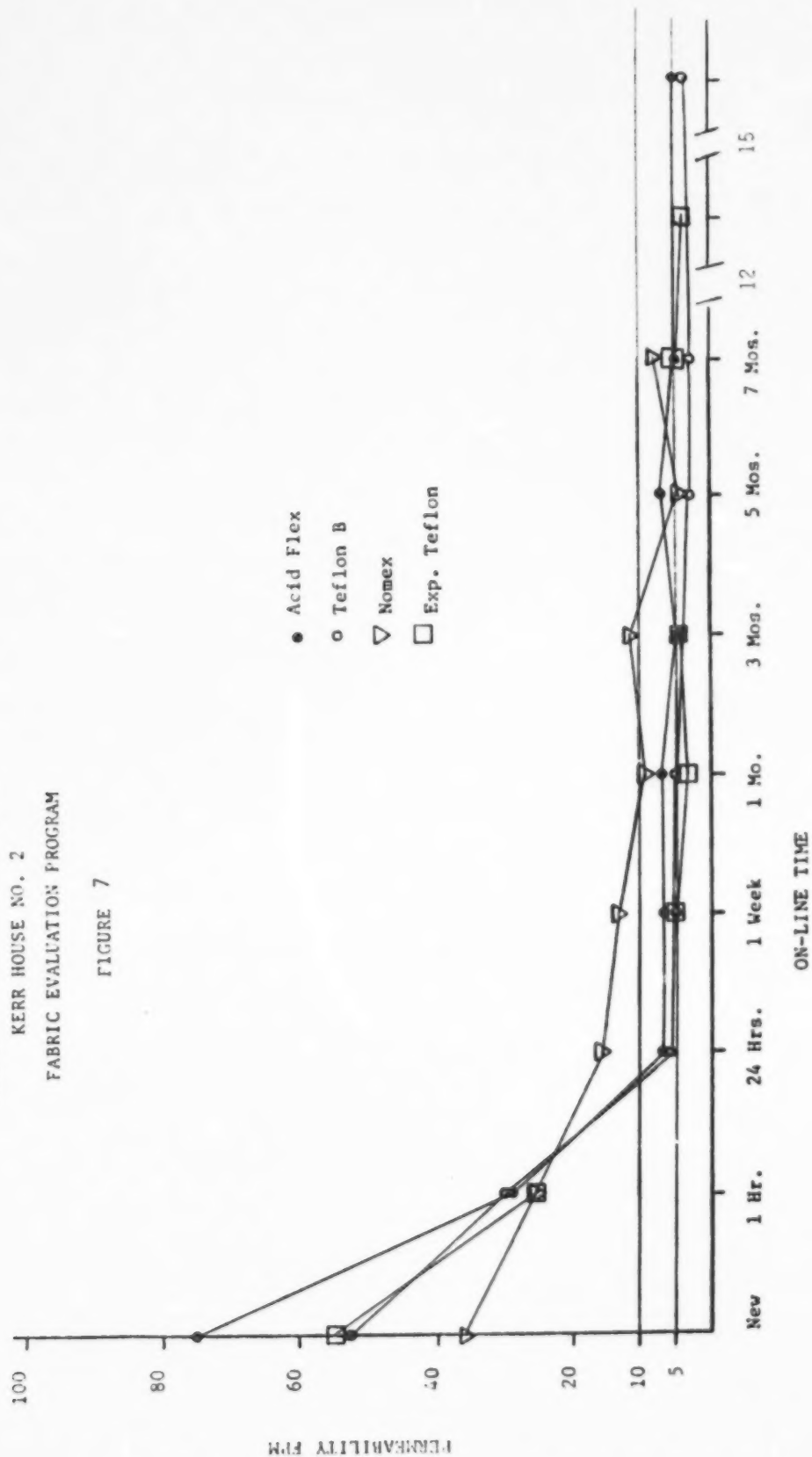
six months and were obtained in May 1982, after restart-up. All the experimental Teflon data were obtained on replacements for the original experimental Teflon bags. This evaluation began in May 1982, and the replacement bags had strength characteristics similar to those of the original bags.

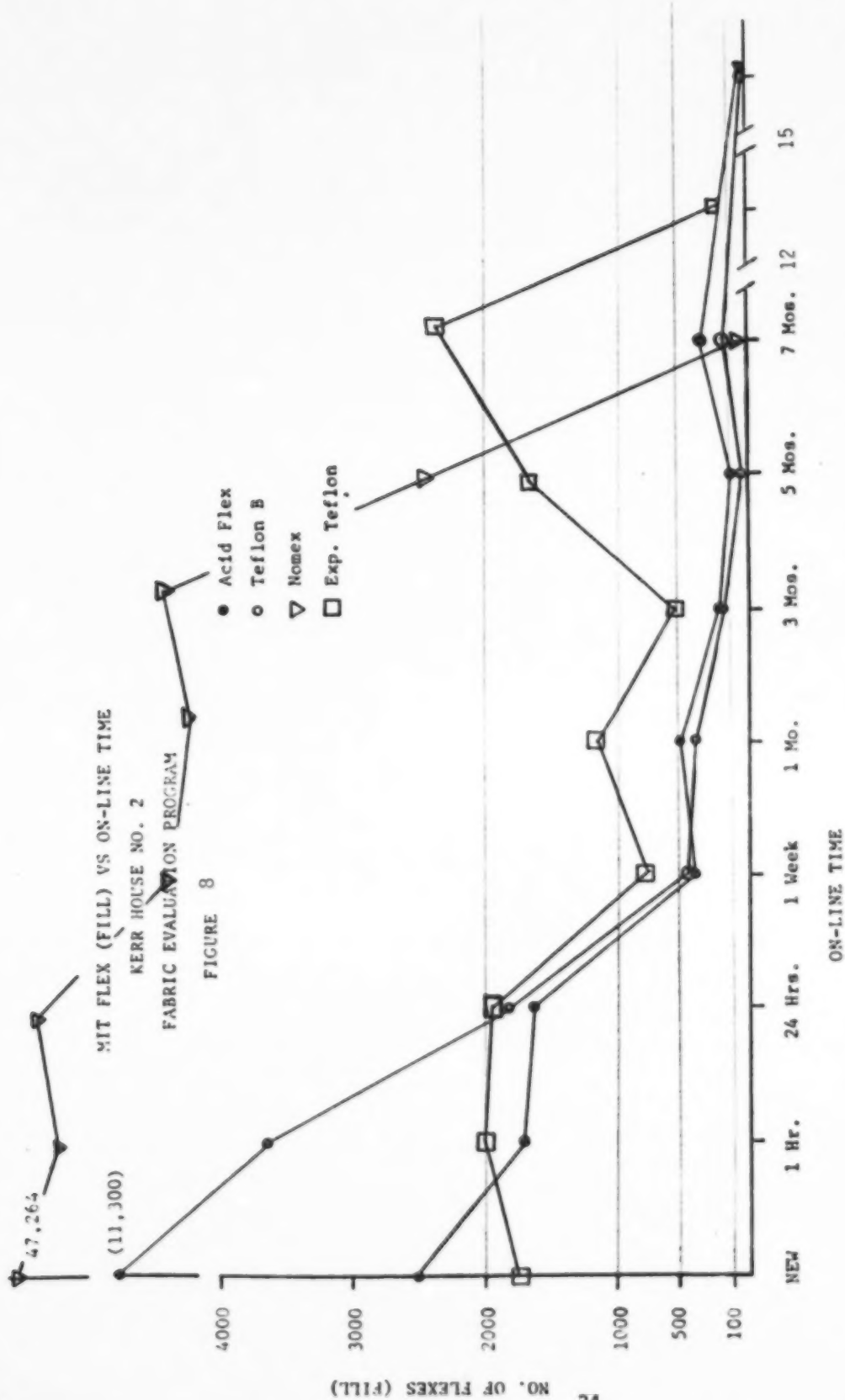
4.2.1) Permeability

As previously stated with regard to the high G/C program, fabric permeabilities were determined in the laboratory. In-situ cake conditions were altered by removal from the baghouse (removal from cages) and transfer to the laboratory. Again, this type of evaluation relies on examining the relativity of the data rather than the absolute values.

As can be seen in Figure 7, the greatest decrease in the permeability of all four fabrics occurred in the first hour of operation. Another substantial decrease took place after 1 hour to 24 hours. The Acid Flex ® bag set had the highest initial permeability, starting 35% higher than the other woven glass fabrics. However, it dropped to the level of the other fabrics (25-30 fpm) within 1 hour. The Nomex ® fabric started with the lowest value; however, it exhibited the least decrease in permeability, and was higher than the other fabrics up to 3 months. All the fabrics were in the range of 4 to 10 fpm within 1 month. Dirty, as-received permeability values of 4 to 10 were normal for fabrics operating at 4-8 in w.g. pressure drops at 4-6/l G/C. At

AS RECEIVED
 PERMEABILITY VS ON-LINE TIME
 KERR HOUSE NO. 2
 FABRIC EVALUATION PROGRAM





three months, all the woven fabrics had roughly the same permeability. From five months on, all fabrics were essentially the same and reflected the sameness in fabric drag seen in the field. Note that no severe blinding occurred in any of the fabrics through 7 months.

4.2.2) Flex Strength

Figure 8 is a plot of the flex strengths for the woven glass fabrics. The Nomex ® felt was considerably higher than any of the woven glass fabrics (initial value around 47,000).

The Nomex ® showed its greatest decrease in flex strength between 24 hours and 1 week (from 42,000 to 9,000). The Nomex bag set showed dramatic loss of strength between 5 to 7 months, and several field failures occurred during this period. The Teflon B ® fabric's initial superiority was eliminated within one day, and this may be of significance to the finisher. Also, the Teflon B ® had the lowest flex value by one month and continued to have the lowest at five months, although only slightly less than Acid Flex ®. The Acid Flex ® fabric showed its greatest decrease to be between 24 hours and one week. The experimental Teflon ® finished bags, although starting at a lower value, showed much less strength deterioration, and bags tested at five and seven months showed virtually no reduction in flex strength.

When the one month old bags were removed for testing, the samples located on the outside walls were very wet. Table 8 is a summary of the flex results for the wet Acid Flex[®], Teflon B[®], and experimental Teflon[®] fabrics. The experimental Teflon[®] showed no significant decrease in flex strength. The Acid Flex[®] showed a significant loss of flex strength only in the middle of the bag, and the Teflon B[®] showed virtually a total loss of flex strength. These are good indications of the finish's ability to encapsulate the fiber and resist moisture and acid attack.

4.2.3) Mullen Burst

Figure 9 showed the Nomex[®] had: the lowest initial burst value, as is typical of felts; a slow decline in strength; stability between one and five months; and rapid deterioration between five and seven months. Of the glass fabrics, Acid Flex[®] and Teflon B[®] showed similar burst characteristic with over 40% strength loss at one month, and only a slight decline to seven

TABLE 8. WET BAG FLEX DATA FOR 1-MONTH OLD BAGS

Fabric	Number of Flexes		
	<u>Top</u>	<u>Middle</u>	<u>Bottom</u>
Acid Flex [®]	811	37	467
	1384	34	588
Teflon B [®]	31	9	43
	26	14	24
Experimental Teflon [®]	1025	1242	614
	1587	912	820

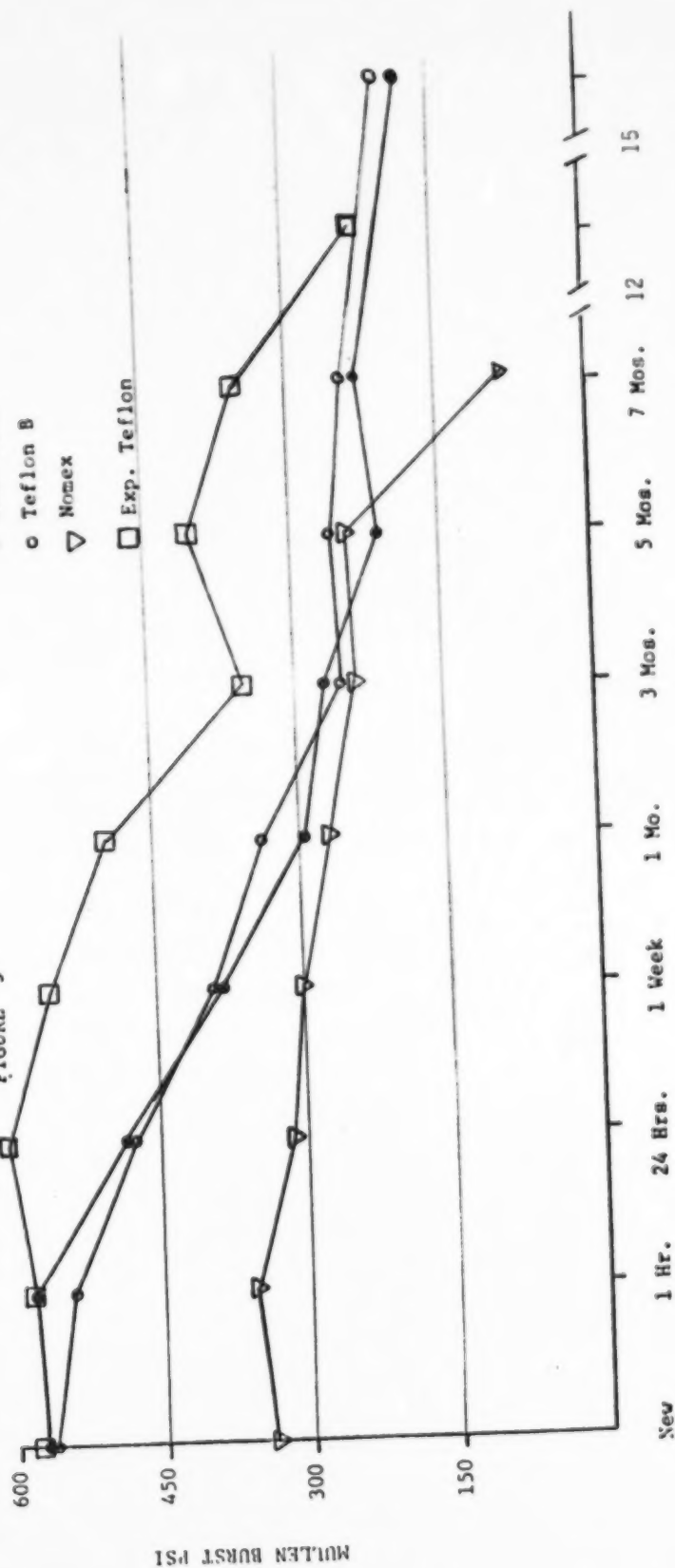
MULLEN BURST VS ON-LINE TIME

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FIGURE 9

- Acid Flex
- Teflon B
- ▽ Nomex
- Exp. Teflon



months. The experimental Teflon ® started with the same burst value as the other woven fabrics (as expected, since all were fabricated with the same basic fabric construction), but showed superior retention of strength.

4.2.4) Tensile Strength

The Nomex ® fabric showed noticeably lower (typical of felts) tensile strength (Figures 10 and 11) than the glass fabrics, but significant deterioration after five months. The glass fabrics show similar trends to each other, with the greatest decrease occurring between 24 hours and 1 week. The experimental Teflon ® again had the highest value after three months.

4.2.5) General Observations

The study, by design, represents a short evaluation period when put in the context of seeking greater than two years of bag life. The data are unique in that they are the first documented evaluation of how rapidly strength characteristics are lost (i.e., hours, days).

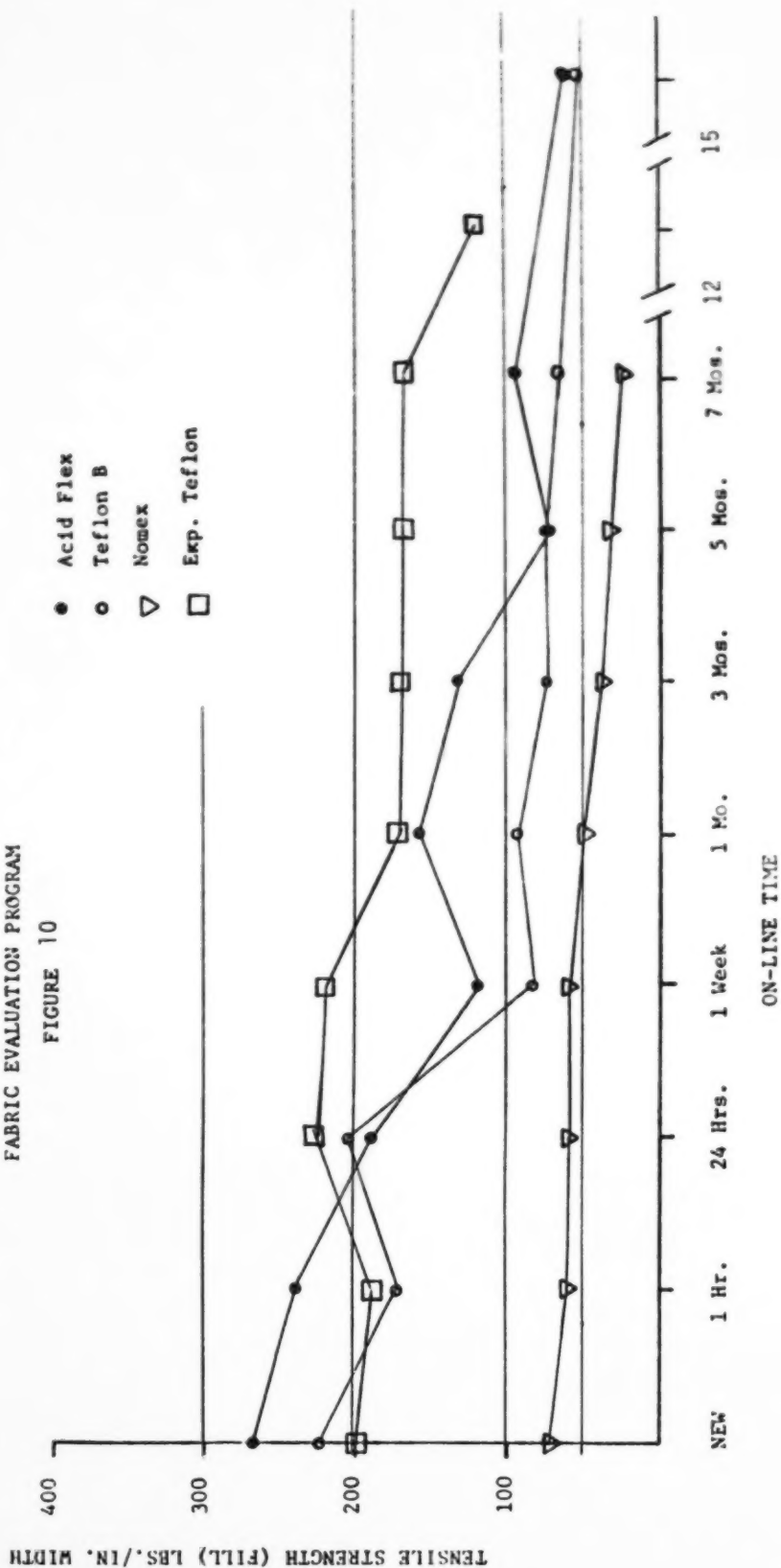
Fabric filters typically show an early strength loss of 50%, at which time they reach a plateau until the end of the bag life cycle. The Acid Flex ® and Teflon B ® appeared to be at this level within one week, and were reasonably stable through seven months on-line exposure plus the extended off-line. The experimental Teflon B ® finish was designed to improve fabric strength

TENSILE STRENGTH (FILL) VS ON-LINE TIME

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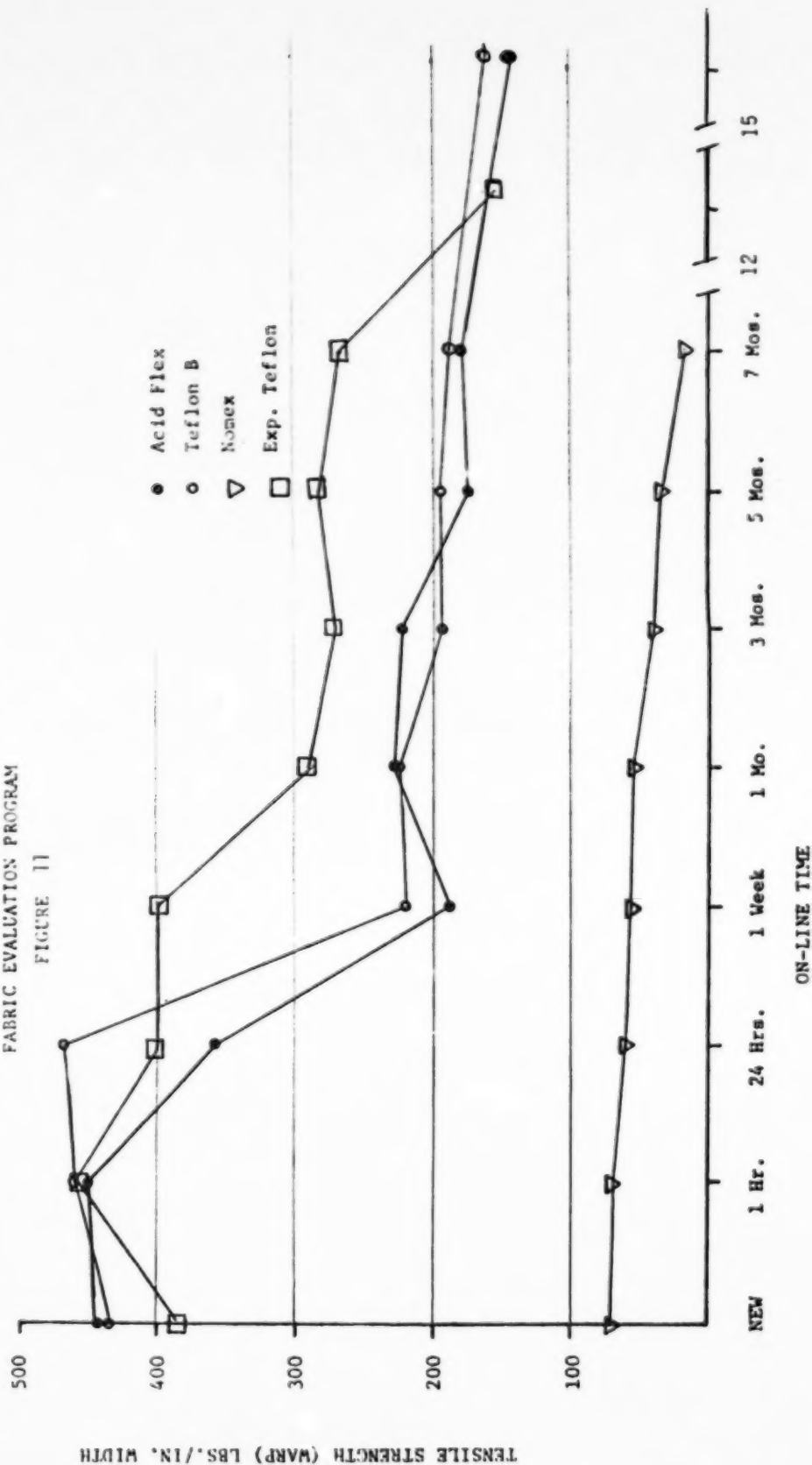
FIGURE 10



TENSILE STRENGTH (WARP) VS ON-LINE TIME
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FABRIC EVALUATION PROGRAM

FIGURE 11



retention and was successful through seven months, indicating that its finish may have protected the fabric better.

The Nomex[®] bag set with its Permagard[®] 6 finish showed superiority over the one month life previously obtained on untreated Nomex[®] but insufficient life to be practical in this application.

Conversion Factors

Readers more familiar with metric units may use the following factors to convert to that system:

<u>Non-metric</u>	<u>Times</u>	<u>Yields Metric</u>
°F	5/9 (°F-32)	°C
ft	30.48	cm
ft ²	0.09	m ²
ft ³	28.32	L (liter)
gr	0.06	g
in.	2.54	cm
in. ²	6.45	cm ²
lb	0.45	kg
oz	28.35	g
yd	91.44	cm

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